1974

FORAGE AND PASTURE RESEARCH NEEDS IN THE SOUTHERN REGION

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Prepared by:

A Joint Task Force of the Southern Agricultural Experiment Stations and United States Department of Agricultural research scientists.

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INTRODUCTION

The Southern Region is composed of thirteen states, Puerto Rico and the Virgin Islands. Although the climate and soil conditions are diverse, the region generally has ample rainfall and a long growing season for forage production. In much of the region, many forage species can be grown over the entire year.

Large acreages of unused land in the Southern Region offer great opportunity to expand the livestock industry (Table 1). The unused land is made up of Class I-IV land listed as "conservation use," "temporarily idle," and "open land formerly cropped." Since the survey was made in 1967, no doubt some of this potentially arable land has been put back into crop production. However, large amounts of land still remaining idle could be best utilized for forage production.

Beef cow numbers are well distributed over the Southern Region (Table 2). The states of Texas and Oklahoma have the largest number of beef cattle while North and South Carolina have relatively few. Dairy cow numbers are also distributed over the Region with the largest concentrations being in Texas, Kentucky, Tennessee and Florida. Sheep are concentrated in Texas. Beef cow numbers have increased throughout the region over the past decade, while dairy cow and sheep numbers have decreased.

The number of cattle in the thirteen southern states has increased 61% or 6,954,000 cows since 1960, and the Southern Region now contains 45% of the total cow herd in the 48 contiguous states.[1] Research has shown that many areas in the South have the capacity to produce large quantities of a variety of forages to support these animals. However, these forages

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[1] Beef Cattle Research Needs in the Southern Region, 1973.

vary greatly in their concentration of digestible nutrients, and there are great differences in animal response to grazing on the wide variety of species that can be grown.

The main justification for cattle, when grain is scarce and needed for human consumption, is their ability to convert forages into high quality protein foods for humans. Grasses and legumes, produced on land not well suited for grain crops, can contribute significantly to man's food supply when processed through ruminant animals. Forage-produced beef may contain less fat and be more nutritious than grain-fed beef. In many areas of the Southern Region, beef could be produced and marketed at lower cost directly off pasture with little or no grain feeding.

The South has more practicable alternatives for providing year-round feed production for livestock than does any other section of the United States. This large number of alternatives demands more research activity aimed towards selection of better production systems.

Forage research is difficult, time consuming and expensive. Cereal research calls for one harvest per year of a reasonably uniform product that can be used to establish the crop again. Forage research requires many harvests per year of a highly variable product that generally cannot be used for establishment. Forages have all (and perhaps more) of the pest problems of the cereals and the additional difficult problems of seed production (frequently 2000 miles away). Establishment problems for forages are more difficult than for cereals. Finally, forages must be fed to livestock and consequently must be evaluated by the response of these animals.

No single discipline working alone can solve the complex problems associated with effective forage production. Geneticists, cytologists, plant breeders, bacteriologists, plant pathologists, entomologists,

Table 1. ACREAGE OF UNUSED CLASSES I-IV LAND AND TOTAL CROPLAND IN SOUTHERN REGION

State or territory	Unused land	Total cropland
	acres	acres
Alabama	1,394,610	4,826,323
Arkansas	1,181,949	8,266,972
Florida	708,161	3,490,189
Georgia	1,661,654	6,331,773
Kentucky	1,003,004	6,061,925
Louisiana	646,349	5,060,796
Mississippi	1,496,996	6,806,993
North Carolina	1,579,706	6,272,284
Oklahoma	2,725,912	12,362,192
Puerto Rico	10,997	338,086
South Carolina	1,116,281	3,785,973
Tennessee	1,540,364	5,981,794
Texas	5,451,156	34,179,771
Virginia	619,708	3,569,737
Virgin Islands	2,191	4,341
Total	21,139,038	65,451,382

Source: National Inventory of Soil and Water Conservation Needs, 1967. United States Department of Agriculture Statistical Bulletin No. 461.

Table 2. CATTLE AND SHEEP ON FARMS, 1974

State	Beef cows that have calved, 1000 head	Dairy cows that have calved, 1000 head	Sheep and lambs, 1000 head
Alabama	1060	110	5
Arkansas	1096	94	6
Florida	1282	212	4
Georgia	935	130	4
Kentucky	1247	302	50
Louisiana	905	138	18
Mississippi	1285	135	8
North Carolina	384	155	12
Oklahoma	2379	126	104
South Carolina	288	57	1
Tennessee	1125	223	21
Texas	6470	350	3200
Virginia	605	160	175
Total	19,061	2,192	3,608

Source: Release of Cattle (United States Department of Agriculture, Statistical Reporting Service. 1974).

nematologists, virologists, plant physiologists, weed scientists and seed scientists must cooperate to develop dependable cultivars with high yield potential. The expertise of soil scientists must be added to learn how to fertilize, irrigate and grow these cultivars most efficiently. Engineers are needed to help develop machines and methods for establishing, harvesting, processing and storing these forages. Animal scientists, chemists, physiologists, pathologists, parasitologists and breeders have an essential input in assessment and effective utilization of these superior cultivars. Cooperative research by scientists of several disciplines focusing on one objective is essential.

Forages in the South must be integrated with the most highly diversified agriculture in the United States. Few southern farmers are interested only in livestock. Thus, livestock and the forages required to feed them must compete with cash crops for land, labor, and equipment. Far too often, cash crops receive the priority.

Many additional scientific man years (SMY) will be required to adequately deal with critical forage problems facing the South's livestock industry. Unfortunately, many well-qualified researchers have inadequate maintenance funds and technical assistance. This has resulted in underutilization of scientific potential. Strengthening existing forage research programs by adding technical assistance and other support until these needs are met may give a greater return per research dollar than increasing the number of SMYs.

The Joint Task Force was directed to identify pasture and forage research needs, formulate objectives and indicate feasible research approaches in Research Problem Areas 102, 207, 208, 209, 307, 308, 309, 407 and 408. Problems relating specifically to the native ranges were assigned to another Task Force. Each Research Problem Area was evaluated in the context of its potential impact on the success of the overall forage-animal production industry in

the Southern Region. Priority needs were identified and assigned to subgroups made up of scientists with expertise in appropriate disciplines. These subgroups then conducted an in-depth study of each problem and specified requirements for achievement of research objectives.

Some specific problems can be identified and solved individually. Heretofore, most research has focused on component parts of the forage-beef or milk production systems. Future research will need to focus not only on the behavior of individual system components but particularly on the mechanisms whereby the components are coupled with each other; e.g., the interfacing of sward and animal in grazing systems. Thus, the Task Force wishes to emphasize the necessity for a fully integrated, interdisciplinary approach to forage-animal production problems.

A successful forage cultivar must be dependable in respect to establishment and production. It should utilize the favorable long growing season in the Southern Region. Warm season cultivars, particularly, should produce forage of improved quality which can be efficiently converted into useable animal product. To achieve these objectives, several areas of forage research deserve special attention:

(1) Collect, evaluate, and preserve forage species now available in the world to provide basic germplasm for improving forage crops.

(2) Breed warm season forage species of superior nutritive value to improve reproduction, efficiency, performance and health of beef cattle.

(3) Breed cool season forage species for improved resistance to pests, greater winter production and improved persistence.

(4) Develop equipment and techniques to improve establishment and management of small-seeded grass and legume swards.

(5) Identify the extent of stand, yield and nutritive value losses from weeds, insects, diseases and nematodes on grasses and legumes.

Develop new and improved chemical, biological and cultural methods for control of these pests in forage crops.

(6) Legume bacteriology - rhizobia strain evaluation for tolerance to high temperature and acid soils, antagonistic effects of competing microflora, and development of technology for improved establishment of symbiotic relationship with host plant.

(7) Develop economically competitive sequential year-round grazing/forage-feeding systems for beef and milk production.

(8) Develop improved and energy-conserving methods for harvesting, storing and feeding forage products of high nutritive value.

Table 3. SUMMARY TABLE SHOWING ALLOCATION OF SCIENTIFIC MAN YEARS (SMY) TO RESEARCH PROBLEM AREAS (RPA) UNDER DIFFERENT LEVELS OF FUNDING

RPA		1972 allocation		Proposed allocation	
Name	No.	National	Southern Region	With 10% increase	To solve problems within 10 years
		SMY	SMY	SMY	SMY
Soil, Plant, Water Nutrient Relation	102	20.0*	6.0*	7.0	23.0
Improved Establ--grasses & legumes	102A			1.0	5.0
Hydrologic Info--grassland watershd	102B			2.0	6.0
Fertilizer use on forages	102C			2.0	7.0
Systems analysis in Grass ecosyst	102D			1.0	2.0
N Fixing Microorganisms	102E			1.0	3.0
Control of Insect Pests	207	44.8	7.2	8.0	22.0
Control of Diseases	208	32.8	11.6	13.0	18.0
Control of Weeds	209	13.2	4.0	5.0	10.0
Weed Control--Forage & Pasture	209A			3.0	5.0
Herbicides in Pasture Soil & Crops	209B			1.0	3.0
Ecological Assoc--Weeds & Forage	209C			1.0	2.0
Biological Efficiency	307	206.6	94.6	105.0	150.0
Germplasm of Forage Species	307A			10.0	20.0
Genetics & Cytogenetics--Forage	307B			20.0	30.0
Breeding Improved Grass & Legumes	307C			20.0	40.0
Mgmt & Breeding for Impr. Quality	307D			20.0	30.0
Impr. Mgmt & Utilization--Forages	307E			35.0	30.0
Mechanization	308	11.4	1.6	3.0	20.0
Methods & Eqpt--Forage Produc	308A			2.0	10.0
Harv, Proc, Storing & Feeding	308B			1.0	10.0
Forage & Pasture Systems	309	5.9	3.6	5.0	20.0
Forage & Pasture Prod Systems Use	309A			4.0	12.0
Forage-Animal Systems	309B			1.0	8.0
Improved Uses of Forages	407	14.4	7.4	8.0	15.0
Pesticides-Forage-Animal Interactions	408	1.6	---	---	12.0
TOTAL		350.7	136.0	154.0	280.0

* Total SMY for RPA 102 (National--199.6) (SR--51.9). It is estimated that of this total, 20.0 SMY at National level and 6.0 SMY at SR level work on forage and pasture.

SOIL, PLANT, WATER, NUTRIENT RELATIONS

RPA 102

IMPROVED ESTABLISHMENT PRACTICES FOR SEEDING GRASSES AND LEGUMES

RPA 102A

Situation: Establishment of desirable forage species is a critical problem in much of the South. There is not enough information on techniques of stand establishment, weed control in new stands, and equipment effective for seeding under diverse conditions. It is necessary to describe favorable microenvironments for emergence and survival of grass and legume seedlings, and to create a suitable microenvironment. Information is needed on how seed size and quality can affect stand establishment. Great genetic advances were quickly made available to farmers when it was shown how to vegetatively propagate, on a commercial scale, plants like Coastal bermudagrass and Pangola digitgrass. Similar advances might be made with outstanding, non-seeding, tall, fescus-ryegrass hybrids if similar methods are developed for vegetative propagation on a commercial scale.

Objectives:

A. To define a desirable microenvironment for emergence and survival of grass and legume seedlings and to develop methods for provision of such microenvironments.

B. To determine the effect of genotype and seed quality on the establishment of forages.

C. To develop practical methods for commercial vegetative propagation of outstanding non-seeding grasses.

Researchable Problems:

A. Improve grass and legume seedling establishment by seedbed modification, innovative approaches to seed placement and improved seed quality.

B. Develop machinery for improved seeding procedures.

C. Define soil and microclimate parameters affecting seedling germination and emergence with emphasis on bringing about favorable changes in these parameters.

D. Define the relationship between establishment and genotypic characters, such as seed size and ability to germinate at variable temperatures and soil moisture conditions.

E. Ascertain the factors affecting successful establishment of vegetatively propagated grasses.

F. Develop machines that will allow successful establishment of vegetatively propagated grasses on an economical commercial scale.

Potential Benefits: Stand failure is one of the greatest sources of economic loss. Development of dependable methods for establishing new stands will reduce production costs, provide for more efficient use of the land resource and result in a significant increase in the production of animal products.

BASIC HYDROLOGIC INFORMATION ON GRASSLAND WATERSHEDS

RPA 102B

Situation: Large areas throughout the South used for producing forage are also important watersheds. These lands must serve as sources of water for off-site use--water that is needed in increasing amounts to meet the needs of agriculture, industry, and municipalities. Grass is second only to a good forest cover in reducing the erosive effects of rainfall, thus reducing the sediment load of runoff water, which is detrimental to water quality. Much of the formerly cultivated land in the sub-humid to humid Southern Region has been allowed to become infested with low-value annual or perennial vegetation, greatly reducing or completely eliminating the value for forage and water production. Other areas remain denuded of vegetation and are critical sources of sediment, which further impairs the quality of water

from these lands. Even in areas where successful revegetation has been achieved, quality of water may be affected by improper use of pesticides and fertilizers. The hydrology of both improved and unimproved grasslands in the sub-humid and humid portions of the Southern Region is not well defined.

Objective: To determine quantitative effects of vegetation management on water storage and runoff of grassland watersheds.

Researchable Problems:

A. Determine the effects of vegetation manipulation on the quality and quantity of runoff water leaving grassland watersheds, including changes in type of cover, stocking rates, method of forage harvesting, grazing systems and agricultural chemical applications.

B. Develop mathematical models that incorporate effects of grassland management upon groundwater recharge, streamflow, erosion, sedimentation

and water quality. These models can be used for planning the management of land and water resources.

Potential Benefits: Success in the envisioned research would provide action agencies concerned with planning multiuse facilities in watersheds and river basins where forage is the primary cover, with improved hydrologic information for flood routing, storage reservoir design and sediment routing. It would also provide maximum utilization of improved grasslands as an effective method of regulating the yield and improving the quality of water while reducing erosion.

NUTRIENT RELATIONSHIPS AND FERTILIZER USE ON FORAGES

RPA 102C

Situation: While yield increases can be obtained through fertilizer applications to forages, these gains are not always translated into improved performance by the grazing animal. Complex soil-plant-animal interrelationships are involved. Non-legume plants generally respond to nitrogen fertilizer with increased forage yields and a higher protein content. With increasing costs of lime and fertilizer, it is important to improve efficiency, particularly in the case of nitrogen. More information is needed on the use of legumes as nitrogen sources for grasses. Losses of applied fertilizers are not only of economic importance to producers but possibly contribute to impaired environmental quality. Thus, the movement of plant nutrients in the soil needs to be better understood.

Legumes respond to additions of phosphorus, potassium, calcium and trace elements when these are deficient in the soil. Increased animal carrying capacity and production as well as erosion protection should result from improved soil fertility practices and higher forage yields. Micronutrients may limit plant and animal growth. Plant and animal toxicities sometimes occur. Toxic quantities of aluminum and manganese in the soil solution are a common problem on many Southern soils. Information is needed on lime requirements of different grass and legume species.

The role of endotrophic vesicular-arbuscular (VA) mycorrhizae in plant nutrition is poorly understood. There is evidence, however, that these fungi increase nutrient uptake and that they make less available forms of phosphorus more available to the host. It cannot be assumed that all species of VA mycorrhizae are equally beneficial.

Objective: To understand the plant-soil-animal interrelationships so that direct fertilizer responses of the plant can be converted into commensurate gains in animal response.

Researchable Problems:

A. Determine the nutrient concentrations in the plant that are necessary for optimum plant growth and their effects on animal production.

B. Identify specific areas of nutrient deficiencies and determine economic efficiency of applied nutrients.

C. Determine plant nutrient availability as affected by soil-water status to ascertain best levels of fertilization to achieve efficient utilization of water.

D. Determine the effect of mycorrhizae fungi on nutrient uptake, plant growth and composition of the host plant at various levels of soil fertility.

E. Determine fate of fertilizers applied to grassland soils.

F. Quantify the nitrogen cycle in grassland soils with emphasis on the processes of immobilization and denitrification.

Potential Benefits: This research will provide a basis for timely and effective fertilization of forage crops and result in more efficient use of applied fertilizers. Benefits will include increased yield and quality of forages, improved animal production, reduced costs and improved quality of runoff water.

SYSTEMS ANALYSIS OF SOIL-WATER-PLANT RELATIONS IN GRASSLAND ECOSYSTEMS

RPA 102D

Situation: Plant growth and water use are part of a complex, interrelated system affected by solar energy, precipitation, soil and other factors. It is important that mathematical models describing the inter-relations of each element of the system be developed in a forage research program. Such models will help identify areas where knowledge is limited and additional research is needed.

Current modeling knowledge involving the water balance and plant growth should be extended to perennial pastures. Data already available from small grassland and brush watersheds can be used in the initial phases of the study to check the validity of the models. In areas where present knowledge is insufficient, experiments must be initiated to determine the relationships.

The models should be designed to provide answers to questions such as: (1) How does animal grazing or other harvesting methods affect the production and water use patterns of forages? (2) What are the hydrologic effects of converting a brush or tree infested area to a highly productive grassland? (3) How will changes in fertility levels affect grass production and the water balance of an area? (4) Which grasses and legumes are best adapted to environmental conditions such as water deficits, temperature extremes and nutrient shortages found in the Southern Region?

Mathematical models such as the one envisioned will be of major benefit in developing optimum management systems for grasslands, regardless of whether the management objective is to produce forage for beef production or to harvest water.

Objective: To develop models for simulating plant growth and the water balance of grassland plant communities.

Researchable Problems:

A. Quantify soil-plant-water-atmospheric relations of grasses growing in mixed plant communities.

B. Develop mathematical models for predicting growth of grasses to include physiological, morphological, and ontogenic development and photosynthetic productivity.

C. Verify such models by measuring evapotranspiration, photosynthesis, and grassland growth.

Potential Benefits: A successful combined model for plant growth and evapotranspiration would be a major step forward in (a) developing pasture management systems to bring about beneficial changes in the use of water and energy, and (b) more accurately predicting the major components of the water balance on grassland watersheds under various management systems to improve the systems for increased water use efficiency.

BIOLOGICAL NITROGEN FIXATION[1/]

RPA 102E

Situation: All forage crops require abundant quantities of nitrogen but little is available from the soil. Therefore, the plant must obtain its nitrogen from nitrogen fixing bacteria or nitrogen fertilizers. Legumes have long been known to have specific rhizobia capable of supplying the nitrogen needed for plant growth. Forage legumes are used in the South to extend the grazing period and to increase forage quality. Without the proper rhizobia the legume will not produce to capacity or compete well with associated tame or wild grasses. Failure of legume establishment has often been shown to be due to improper inoculation.

Grass production requires much nitrogen fertilizer because grasses do not have a highly developed symbiotic system to supply nitrogen. Development of such a system for grasses would revolutionize the efficiency of food production and conserve fossil fuels. Recent research in the tropics has indicated that nitrogen fixing bacteria do have a close association with the roots of some grass species and are capable of fixing significant quantities of nitrogen for plant growth. The estimated rate of fixation in the rhizosphere of some grasses, was 1 kg/hectare/day.

Objectives:

A. To determine the cause of unsatisfactory forage legume nitrogen fixation and develop methods to improve the dependability of this process in the field.

B. To determine and develop the ability of present forage grasses to support and significantly benefit from nitrogen fixing bacteria.

Researchable Problems:

Legumes

A. Determine the nitrogen fixation pattern of legumes grown under condi-

[1/] R. Weaver assisted in preparation.

tions of stress imposed by the environment and management.

B. Isolate, or develop by genetic manipulation, highly effective strains of rhizobia better able to survive in soils of low pH and high temperature.

C. Develop inoculation techniques that enable the inoculum rhizobia to compete favorably with ineffective soil rhizobia for nodule sites.

D. Establish a laboratory that maintains Rhizobium cultures for use on legumes grown in the South.

E. Develop a better method for enumerating the rhizobia in soil that are capable of nodulating a specific legume.

Grasses

A. Determine the amount of photosynthate made available by grasses that can be used in supplying energy to nitrogen fixing bacteria.

B. Determine the amount of nitrogen fixation that presently occurs in the rhizosphere of different grasses.

C. Isolate highly efficient nitrogen fixing bacteria and establish them in the rhizosphere of grasses that supply enough energy material for significant biological fixation of nitrogen.

Potential Benefits: Establishment of a scientific basis for management of symbiotic nitrogen fixation. Maximizing the nitrogen fixation by legumes will make them more competitive with associated grasses and bring about more efficient production.

Establishment of a system for biologically supplying the nitrogen needs of grasses would greatly reduce the cost of production and substantially reduce the fossil fuel requirements in the production of grasses. It was estimated that 1/3 of the energy requirements were due to using nitrogen fertilizers.

DEVELOPMENT OF ECONOMICAL INTERGRATED MANAGEMENT PROGRAMS FOR CONTROLLING INSECT PESTS.

RPA 207

Situation:

At present, insect-related problems on forage are not adequately understood and in several instances the insect species involved and the magnitude of damage attributable to certain insect species are unknown. In many cases, methods for control are not available, inadequate or too expensive. More acres will be devoted to the expanding livestock industry in the South, which will cause the insect pest problem to expand in area and magnitude. Integrated methods of insect control are especially relevant to forage crops which often have lower values than row crops per acre and which cannot tolerate high residues of pesticides. Increasing resistance in insect pests to available insecticides and the decreasing ability of industry to produce economically effective insecticides with new modes of action greatly accentuate the need to develop new management systems to help maintain pest species below established economic threshold levels.

Objective:

To develop practical, economical pest management systems for key insect pests attacking forage, pasture and range crops.

Researchable Problems:

1. Identify insect species (including vectors of plant diseases) and the role they play in limiting the production of forage, range and pasture crops.
2. Determine the life history, seasonal occurrence, ecology, population dynamics and behavior of pests (including crayfish) and beneficial species.

3. Determine effects of environmental factors such as photoperiod, light quality and intensity, temperature, and moisture on key pest and beneficial species.
4. Determine insect sampling procedures to establish economic threshold levels and economic injury levels for key harmful species.
5. Investigate and develop non-insecticidal methods of insect control emphasizing:
   (a) physical and/or biochemical nature of insect resistance in host plants,
   (b) development of cultural control practices,
   (c) utilization of predators and parasites,
   (d) insect control by pheromones, hormones, irradiation, chemosterilants and other physiological methods.
   (e) incidence and importance of natural pathogens in regulating pest populations.
   (f) use of autocidal methods for controlling key pests.
6. Increase screening and developmental efforts to produce new, effective and more selective chemicals (insecticides, chemosterilants, attractants, repellents, feeding stimulants, deterrents, etc.) for pests, and determine their toxicity, persistence and biodegradability in the environment.
7. Establish economical and feasible guides for using minimum rates of insecticides with proper timing of applications for maximum benefit and to minimize residue hazards in forage crops.
8. Develop necessary data for developing and verifying key mathematical insect models that can be integrated with plant models for simulation and predictive modeling to provide more effective research

guidance and resource management.

9. Develop integrated pest management programs for key pest species utilizing various combinations of above approaches, keeping in perspective, economics and practicability.

10. Study effect of developed pest management programs on population dynamics of pest species, beneficial arthropods and wildlife.

Potential Benefits:

Benefits expected to accrue from this research include biological and ecological information necessary to initiate sound control investigations, reduction in use of insecticides and adjunct dangers to man and his environment, reduced costs of production of forages and more efficient and permanent insect control.

CONTROL OF PLANT DISEASES AND NEMATODES

RPA 208

Situation: Fungi, bacteria, viruses and nematodes attack forage legumes and grasses and cause considerable losses each year. The losses may be slight or complete on individual fields and depend on the area, crop, weather condition and presence of the pathogen. Many different pathogens are involved, and all parts of the plants are subject to attack.

Root and crown rots, caused by a wide range of fungi and bacteria, are known to be associated with both establishment and longevity problems of forage legumes and grasses. Root deterioration of legumes in the northeastern U.S. has been shown to be caused by several organisms, including at least 5 species of *Fusarium*. There is also evidence that viruses are involved. The causes, and effects of environmental conditions, on this disease complex in the Southern Region are not known. The effect of rotations with various legumes and grasses on root rot severity is understood poorly.
Basic research is needed to determine the roles of host age, predisposing stresses caused by management and utilization, genetic deficiencies, temperature, moisture and other microorganisms on the disease syndromes.

Viruses are common in forage legumes. They have been associated with non-persistence of perennial species, and have eliminated annual yellow lupine in Florida where 500,000 acres were grown for pasture in the late 1940's. The entire virus complex on forage legumes needs increased research efforts to determine their importance in reduction of yields.

Little is known about losses caused by nematodes attacking pasture and forage crops because research in this area has been virtually non-existent. Preliminary research has indicated that nematodes attack and cause considerable amounts of disease in sorghum and millet hybrids and in forage

legumes. A concerted effort by nematologists and geneticists should be made to find nematode resistance that can be used in new cultivars and breeding lines of both grasses and legumes.

Rusts and leaf blights of pasture grasses are often a problem in the southern United States. In recent years, strains of rust have appeared that cause considerable damage to tall fescue. A rust on pearl millet new to the U.S. was first observed in 1972, and it was serious in fields where it occurred. Also, Piricularia leafspot on pearl millet has become more important in recent years.

Many of the high quality cool season perennial forage grasses that are used in other parts of the U.S. and other countries do not persist in the southeastern United States. This failure to persist is principally a result of increased pressure from diseases, nematodes and insects in a warm humid environment.

Objective: To increase yield and quality of pasture and forage crops by controlling plant diseases and nematodes. Develop persistent cultivars with multiple disease and nematode resistance.

Researchable Problems:

A. Identify the pathogens involved in root and crown deterioration of forage legumes. Study the effects of environmental conditions, rotations, management, and saprophytic microorganisms on the severity of deterioration. Develop methods for reducing root deterioration.

B. Develop cultivars of forage legumes resistant to viruses.

C. Elucidate the effect of the entire virus complex on forages.

D. Determine losses of pasture and forage crops in the Southern Region caused by nematodes and develop cultural methods of control.

E. Develop forage grass and legume cultivars resistant to nematodes.

F. Develop forage grass cultivars resistant to rusts with particular emphasis on tall fescue and pearl millet.

G. Determine the importance of leaf spots and blights of both grasses and legumes. Devise methods of control utilizing fungicides, crop rotations, destruction of nearby weeds on which the pathogens may survive and resistant cultivars.

Potential Benefits: It is estimated that diseases and nematodes on grasses and legumes cause forage yield losses of 15%-25% annually. Development of resistant cultivars and new methods of control could reduce these losses considerably and provide forage of higher nutritive value.

CONTROL OF WEEDS

RPA 209

IMPROVEMENT OF WEED CONTROL METHODS IN PASTURE

RPA 209A

Situation: Weeds exert their most competitive, damaging effect upon slow-growing seedlings of forage species. In establishing forage crops the pre-existing vegetation needs to be controlled or suppressed in order to achieve vigorous growth and a full stand of the new species. Weeds often present a major barrier to rapid growth of legumes planted in association with existing forage grasses. New plantings of vegetatively propagated grasses are adversely affected by competition from even moderate weed infestations. Herbicides available for use in suppressing competition during establishment lack efficiency and effectiveness, and costs of herbicide in these situations frequently preclude their use.

Methods available for controlling a number of problem weeds in Southern pastures and forage crops are inadequate, ineffective or not economically feasible. Many farmers use a disc to renovate a pasture, but the effectiveness of this method is questionable and the energy requirements are great. Annual and perennial broadleaf and grass weeds compete vigorously with desirable forage species, and many weed species are toxic to grazing animals. Margins of selectivity between grass weeds and forage grasses or between broadleaf weeds and legume forage species are not sufficient in many instances to control the weed without injury to the desirable pasture species.

Estimates of losses from weeds would be useful as an indication of the need for additional research, and as a guide to the severity of the weed problem. Accurate data on the costs that weeds create in pasture and forage production are needed as background information upon which

to judge the value and feasibility of alternate control procedures.

Objective: To develop new and improved methods for weed control in the establishment of forage crops, and to develop and improve methods for safe, effective, and economical control of problem weeds in Southern pastures and forages.

Researchable Problems:

1. Determine the competitiveness of weed species that limit establishment of new stands or interseeding of desirable forage species. Develop improved methods of weed control with herbicides.
2. Evaluate the use of contact and selective herbicides to suppress top growth of warm-season perennial forage grasses in early autumn for successful overseeding and establishment of cool-season annual grasses and legumes.
3. Evaluate newer herbicides for suppressing or eliminating weeds competing with vegetatively propagated grasses.
4. Evaluate newly developed herbicides for potential use in controlling troublesome weeds such as horsenettle, wild garlic, smutgrass, curly dock, dogfennel, little barley, thistles, broomsedge and sandbur.
5. Improve methods and timing of application of herbicides to improve control and minimize problems of limited selectivity.
6. Evaluate rate and total dosage of herbicide application and stage of growth of both weed and forage species in relation to extent of control and limiting injury to the desirable species.
7. Determine the safety and specificity of herbicides used to control weeds in pastures in relationship to varietal susceptibility or

or tolerance to each herbicidal chemical.

8. Evaluate mechanical versus chemical weed control procedures.
9. Establish accurate measure of the yield losses in each category of the pasture and forage crop production system caused by variables of weed species, weed density and duration of competition. Determine all components of cost and loss in specific weed-crop combinations to identify the threshold level where weed control procedures become economically feasible.

Potential Benefits: Use of herbicides remains the single most effective method for controlling weeds. It has been estimated by the Southern Weed Science Society's Committee on Economic Losses that the cost of weeds in pastures exceeds 500 million dollars. Much of this loss can be regained to the economic advantage of the producer and consumer by limiting or eliminating the losses in yield and quality, the extra costs involved in harvesting, and the loss in land value that are attributable to weed infestations.

MODE AND MECHANISM OF ACTION OF HERBICIDES AND THEIR FATE IN PASTURE SOILS AND CROPS

RPA 209B

Situation: Herbicides remain the primary means of controlling weeds effectively in pastures. Because of the large number of different pasture weed and forage species, detailed knowledge of how herbicides affect each is not available.

The fate of herbicides in pasture species and in soils on which they are grown must be thoroughly established, both for safe use of the herbicide and for an understanding of the most effective and economical procedures to control weeds.

In order to design improved methods for controlling weeds, fundamental information is needed about how herbicides kill weeds and how desirable species successfully avoid the damaging effects of a weed-killing chemical. Knowledge concerning both the mechanism of action and the metabolic fate of an herbicide form the foundation for synthesizing and formulating more selective analogs, or entirely new compounds, with improved effectiveness.

Residues of herbicides and their major metabolites in forage crops could serve as major deterrents to the effective use of herbicides in pasture weed control. Data are needed particularly for minor crops or minor uses of herbicides.

Objective: To improve effectiveness and safety of herbicides by research on the mechanism of herbicide action in weeds and on the fate of herbicides in crops and soils.

Researchable Problems:

1. Determine the mechanism of action of newer herbicides in southern-grown weeds and forage species.

2. Develop efficient and effective techniques for herbicide residue analysis and their major metabolites in forage species.
3. Assess the metabolic fate of established and new herbicides in pasture crop plants and in associated weeds, with particular attention given to the occurrence of metabolites in edible portions of forage species.
4. Determine the occurrence and longevity of herbicides and their major metabolites in soils that are important in pasture production in the South.

Potential Benefits: A more complete understanding of the means by which herbicides kill weeds, and of the fate of herbicides in crop plants, can be expected to lead to more effective, efficient and safer use of chemicals to control weeds. Determination of herbicide and metabolite residues in crops and soils is critical for registration of herbicides for pasture management.

ECOLOGICAL ASSOCIATIONS OF WEEDS AND FORAGE CROPS

RPA 209C

Situation: There are at least 30 major annual and perennial grass and broadleaf weed species that compete successfully with forages in the South. Others of more limited distribution, as well as woody plants, species that are poisonous or irritating to cattle, contribute significantly to the problems associated with forage productivity.

Little is known concerning the life history and population dynamics of any of the troublesome weeds in pastures of the South. Growth characteristics, reproductive potential, spreading rate of propagules, competitive advantages and reaction to environmental variables are largely unknown or inadequately described.

Successful control of one or more weed species frequently permits accelerated development of others that have greater resistance to available control methods. Frequently, a competitive advantage is obtained by a selected few species when other species are removed.

Objective: To provide for improved control of weeds in forage and pasture crops by better understanding of the population dynamics of weeds.

Researchable Problems:

1. Determine the dynamics of weed populations as related to specific forage production practices, and describe ecological changes that occur under different management systems.
2. Evaluate ecological shifts in weed populations that occur in relation to different weed control or pasture management practices.
3. Describe life histories of major weeds as they are influenced by forage production practices.
4. Evaluate the interspecies competition among weed species and the nature of direct competitive effects of weeds on forage crops.

Potential Benefits: A fuller understanding of the life histories of problem weeds, as well as their interaction with associated weeds and forage species, will provide the basis for selection of appropriate weed control techniques. Ecological studies will also aid in the prediction of new weed problems that could occur under different management regimes. This would serve as a base for designing new weed control methods before new weed problems become acute.

BIOLOGICAL EFFICIENCY

RPA 307

Biological efficiency may be described as the degree to which an organism achieves its maximum genetic potential for a life-related process in a particular environment. Thus the concept of improving biological efficiency encompasses research on all biologically related factors which may increase the output of product from the same or smaller increments of the resources necessary for production. Researchable problems in forages include efforts to improve genetic potential through breeding, modification of environmental factors, management systems and utilization practices designed to make maximum effective use of the forage produced. The research areas included in this RPA are too diverse and too complex to identify in one "Situation" statement. Each area presents unique problems and possibilities and requires competence in a particular discipline(s). Therefore, the Task Force has divided RPA 307 into five broad areas for clarity of assessment of the situation and research approaches. Actual conduct of the research, however, will require a team approach for maximum effective progress.

COLLECTION, EVALUATION, CHARACTERIZATION AND PRESERVATION OF GERMPLASM OF WORLD'S FORAGE SPECIES POTENTIALLY VALUABLE IN THE SOUTHERN REGION

RPA 307A

Situation: The need for superior grass and legume cultivars which can be effectively and efficiently established and managed in southern pastures is critical and ever-increasing. Present forage cultivars will not meet the needs of the rapidly expanding livestock industry in the Southern Region. Millions of acres of land in the South, potentially productive for pasture and range, remain essentially barren or covered with useless vegetation. Much of this economic loss is due to the lack of adapted species. Even in our best species there are critical weaknesses which can and must be constantly improved through breeding. Long range improvement of present cultivars and discovery of new adapted species will require a continuous input of new germplasm and diligent search for promising new forages.

Many of our most important forages are introduced species, and new germplasm must come from the native habitat. Apomictic reproduction is common in the perennial grasses and effective improvement of these species requires sexual plants which are frequently available where the species originated. The world's native grasslands represent a rich storehouse of potentially valuable species, many of which are growing on sites similar to our critical problem areas. These species offer considerable promise for our needs if sufficient effort is devoted to collection of plant materials and modification where necessary through breeding. It is imperative that this valuable germplasm be collected, evaluated and preserved while relatively undisturbed natural habitats still exist. Plant breeders familiar with breeding problems and specific needs should provide leadership in planning, participate in exploration and conduct evaluation of accessions.

Objective: To provide a permanent storehouse of valuable forage species and germplasm as a resource for immediate and future improvement of southern pastures.

Researchable Problems:

1. Plan and conduct systematic exploration of appropriate natural habitats and collect species with immediate and future potential for improvement of southern pastures.
2. Evaluate and characterize all plant materials for adaptation, contribution of germplasm and potential for modification through breeding.
3. Devise effective system for permanent preservation of materials with particular emphasis on accessability to genes of major importance in current breeding programs.

Potential Benefits: Undisturbed natural habitats, the storehouse of evolutionary products from eons of natural selection, are rapidly disappearing as developing countries intensify their agricultural industries to meet the needs of rapidly increasing human populations. Once destroyed, this valuable natural resource cannot be replaced. Accumulation of valuable germplasm and potentially useful species would enhance present forage breeding research and assure that nature's supply of valuable genetic variability is available to meet future objectives.

DEVELOPMENT OF FUNDAMENTAL GENETIC AND CYTOGENETIC INFORMATION AND EFFECTIVE BREEDING METHODS FOR FORAGE GRASSES AND LEGUMES.

RPA 307B

Situation: Forage crops encompass many diverse species characterized by unique reproductive systems, complex cytology and perfect flowers which are often so minute that mass emasculation and hybridization is impossible. Various mechanisms of apomixis, cleistogamy, polyploidy, chromosome irregularity and taxonomic problems are common among forage species and impose serious limitations in the use of conventional breeding methods. Continuous cytogenetic and cytotaxonomic investigations are necessary in forage breeding in order to solve reproductive problems, establish relationships and develop appropriate breeding techniques. With complex forage species, efforts to improve breeding methods have been rewarding but much remains to be accomplished. Each species, and often individual ecotypes, pose new challenges and new possibilities.

There is an immediate need for research on methods for greater use of heterosis, hybridization techniques, most effective progeny for evaluation of selections, genetic gain through recurrent selection and performance of hybrids and synthetics through several generations. Male-sterile lines and restorers offer considerable promise for production of hybrid forage grasses, and efforts to identify and isolate these stocks need to be intensified in forage species. Apomixis poses both problems and possibilities in forage crop breeding. Control and manipulation of obligate apomixis should be fully exploited, and techniques are needed for suppression of sexuality in facultative apomicts. Investigation of methods to vegetatively propagate bunch grasses is needed to provide an effective means for use of sterile but otherwise superior strains. Information is needed on the potential of interspecific and intergeneric hybridization, mutation breeding and the

inheritance of important characters. New, unique and more efficient breeding methods are required for development of an adequate range of improved cultivars with a broad germplasm base and minimum genetic vulnerability.

Objective: Develop superior breeding techniques for forage species through genetic, cytogenetic and breeding behavior investigations.

Researchable Problems:

1. Develop fundamental cytogenetic information on reproductive and cytological phenomena which prevent effective breeding and/or have potential for use as breeding tools in the improvement of forage grasses and legumes.
2. Determine taxonomic relationships of forage species so that breeding material can be more effectively utilized, and investigate interspecific and intergeneric hybridization for transfer of desirable genes or to gain heterosis.
3. Intensify search for male-sterile lines, fertility restorers, genetic marker stocks and self-imcompatability systems, and apply the results in development of superior hybrid cultivars.
4. Investigate basic nature and genetic control of apomictic mechanisms to allow for manipulation of apomixis as a means for rapid transfer of genes and permanent fixation of genotype in F_1 hybrids and interspecific transfer of genes for mode of reproduction. Develop effective techniques for suppression of sexuality in facultative apomicts
5. Determine inheritance of important characters, role of inbreeding, and effective systems for utilizing heterosis in polyploid complexes. Explore methods to vegetatively propagate bunch grasses to overcome limitations imposed by sterility.

6. Improve breeding methods for rapid development of nutritious forage varieties having combinations of pest resistance, high production potential and greater dependability.

POTENTIAL BENEFITS: Solution of major cytological and reproductive problems of forage species will permit development of rapid and effective breeding techniques. Enhancement of the breeders skill will result in a continuous flow of highly productive, nutritive, dependable forage cultivars for support of an expanding livestock industry in the Southern Region.

BREEDING IMPROVED GRASS AND LEGUME FORAGE CROPS FOR THE SOUTHERN REGION

RPA 307C

Situation: The beef and dairy industries in the Southern Region are presently based on the production and utilization of only a few major forages. The future growth and economic status of these industries depends largely on the ability of the plant breeders to provide an array of new and improved cultivars of forage crops. The diversity of climate, soils and animal production systems in the region impose special requirements that cannot be met by relying on a few species and cultivars. The prevalence of serious disease, insect pests and numerous problems associated with management and utilization of forages necessitates constant revision and expansion of objectives in forage breeding. Higher costs of grain and protein supplements, expensive fertilizer and energy and labor shortages have increased the need for new forage cultivars having higher yield, better quality and greater dependability.

Present forage cultivars can be improved significantly by developing and combining germplasm with superior pest resistance, higher quality, better persistence under intensive management and high reproductive capacity. Research has shown that genetic variation exists for these factors and the development of new improved cultivars of several species can now be accelerated. There is a critical need for cultivars with greater usefulness on difficult sites and areas now barren or occupied by useless vegetation. Grass and legume cultivars tolerant of aluminum and manganese on acid soils would make it possible to reduce the amount of lime needed and permit them to be grown over a wider range of conditions. Breeding of cultivars for specific sites and special uses such as wild game, conservation and enhancement of environment

is realistic and must be a part of our overall efforts to improve the quality of life of all our citizens.

Objective: To develop dependable annual and perennial forage cultivars with high genetic potential for forage yield and quality, seed production, seedling vigor and resistance or tolerance to pest and environmental hazards.

Researchable Problems:

1. Identify factors limiting forage production and utilization that may be overcome through breeding.
2. Determine the economic value of major objectives such as disease and insect resistance, dwarfness, drouth tolerance and tolerance to soil acidity.
3. Develop rapid screening and evaluation techniques for pest resistance, tolerance to environmental hazards and other components of biological efficiency. Isolate germplasm and determine heritability of specific components.
4. Develop superior forage cultivars that combine seedling vigor, disease, insect and nematode resistance, high yield and quality, good seed production, adaptation and persistence under intensive management.
5. Develop cultivars tolerant of aluminum and manganese in acid soils. Determine the mechanism of tolerance to these toxic elements in adapted grasses, legumes and associated rhizobia.
6. Develop germplasm and cultivars for use on difficult sites or for special purpose use such as wildlife, conservation and enrichment of environment.
7. Develop systems for extensive evaluation of germplasm in the Southern Region.

Potential Benefits: New and improved forage cultivars will increase beef, dairy and sheep production, cut costs of production, help maintain relatively stable prices and increase farm profit. A strong and consistent forage development program will provide a sound and permanent base for the Southern Region's livestock industries. Development of forages for different sites will assure revegetation of vast areas of wasteland, enhance the quality of water and air, support wildlife and recreation and improve the quality of life of all citizens in the Region.

MANAGEMENT AND BREEDING OF FORAGE SPECIES FOR IMPROVED QUALITY

RPA 307D

Situation: Forage quality is determined by the net effect of physical and chemical characteristics of a forage and is ultimately expressed in animal intake and performance. While overall quality is relatively easy to express in terms of animal production, individual components which affect quality are difficult to identify and isolate. Quality is influenced by many factors which have plus or minus effects on acceptability, digestibility, growth and reproductive processes of the animal. Fortunately some, and perhaps most, chemical and morphological factors affecting quality are heritable and significant improvement through breeding has been demonstrated. Since improvement in the quality of a particular forage represents a clear economic gain with little or no additional cost input, efforts to improve quality through management practices and breeding deserve maximum consideration in planning forage research.

Difficulties in evaluating forage quality and identifying specific components which affect quality restrict maximum breeding progress. *In vitro* dry matter digestibility determination has been very useful in estimating quality but more refined techniques are needed for identification of specific chemical and structural factors which may be affected by management practices or can be modified through breeding. More research is needed to characterize fibrous and biochemical constituents alkaloids, phenols, glycosides and tannins present in forage plants and determine their affects on intake and digestibility. Anti-quality factors have been identified in several forage crops, but information is lacking on heritability of these factors or methods of substantially altering

their presence in plant tissues. The effects of forage management, processing, storage and handling on forage quality requires investigation. Information on correlation of results of laboratory determinations with animal performance are needed to assess the accuracy and reliability of these results for predicting nutritive value of the forage and for use as selection criteria in a breeding program. Research is needed to develop management practices that aid in maintaining forage nutritive value and minimize fluctuations in quality due to stage of growth, environment and species composition.

Objectives: To develop reliable techniques for characterization of forage quality, develop management practices that ensure maximum quality of plant material, and breed higher quality forage cultivars with greater potential for economical and sustained animal performance

Researchable Problems:

1. Develop techniques for rapid and reliable assessment of forage quality characteristics.
2. Identify and evaluate chemical, anatomical and morphological characters of forages that affect digestibility, animal intake, selective grazing and nutrition, and investigate the effects of management and cultural practices on these characters.
3. Identify techniques for managing forages and handling and processing harvested forage that ensure maximum quality of plant material.
4. Determine heritability of quality characters and combine quality factors with multiple disease and insect resistance, greater responsiveness to water, light and nutrients and develop cultivars with genetic potential for maximum production of digestible nutrients per unit of land.

Potential Benefits: Improvement in forage quality is reflected in more efficient and economical animal production, better reproductive efficiency and more effective use of our land resource. High quality forages substantially reduce the need for supplemental feeding of grazing animals and allow the producer the option of marketing heavier animals with some degree of "finish".

IMPROVED MANAGEMENT AND UTILIZATION PRACTICES FOR SOUTHERN FORAGES

RPA 307E

Situation: Critical problems exist in maintaining the productive life of Southern pastures and in achieving maximum utilization of growing plants with minimum stress on growth, development and longevity. The fact that forage utilization involves periodic and often drastic removal of much of the photosynthetic area imposes serious biological problems. Trampling and other factors associated with intensive grazing create a situation of continuous stress on growing plants. There is a serious shortage of well established principles of management and utilization of forage crops to ensure maximum biological efficiency of both plants and animals. Problems of immediate concern in forage management include determination of optimum regrowth intervals between harvests, best intensity of defoliation, most effective time and rate of fertilizer application and practices that favor maintenance of stands, high forage production and superior quality of forage. More information is needed on all aspects of plant-animal interactions in long range pasture systems.

Increased emphasis must be placed on the utilization of forages by animals as affected by forage production variables and other treatments. Data are required on production/animal, animals/hectare and production/hectare in order to evaluate the economic efficiency of forage utilization systems. Research is required on voluntary intake, nutrient digestibility and feed conversion in order to relate forage production to forage utilization in mathematical models of forage-animal systems. The prediction of forage quality by characterizing small samples of forage remains an essential part of the total effort in forage research. Innovative approaches are required in order to establish those chemical, anatomical and morphological

characteristics which control voluntary intake, nutrient digestibility and efficiency of nutrient utilization. Development of rapid, routine procedures is essential, but these procedures must be based on rational cause-effect relationships if they are to be applicable to a wide range of forage genera, species and cultivars. Prediction of forage consumption is an important component in developing mathematical models of forage-animal systems. Consumption is the link between forage production and forage utilization and is affected, in large part, by forage characteristics. These are, as yet, not completely understood.

Objective: Improve present concepts and develop new concepts in forage production, quality evaluation and animal grazing and feeding systems.

Researchable Problems:

1. Evaluate the effects of forage production variables on forage yield, maintenance of healthy productive stands and utilization of forages by animals.
2. Determine the relationships between forage characteristics and forage quality and modification of these by management and utilization practices.
3. Provide essential information on the behavior of the pasture component, the animal component and how they interact; define the effects of stocking rate on productivity of the sward and the animal, and evaluate animal factors (e.g. grazing behavior) affecting productivity of the sward.
4. Relate the voluntary intake of pasture forage by grazing animals to plant and animal variables, improve techniques for measuring pasture intake by grazing animals and improve methods for prediction of forage quality.

5. Determine and characterize interactions between forage quality and nutrient requirements of various classes of livestock (e.g. growing steers, brood cows, dry or lactating, lactating dairy cows, etc.) and livestock with increased production potential, such as "twinning" or crossbred beef cows.

Potential Benefits: Evaluation of forage production variables in terms of forage utilization by animals and sustained productivity of pastures will make possible the selection of production-utilization combinations which can improve the economic efficiency of the appropriate forage-animal system. Development of improved quality prediction procedures will help to increase the rate at which new forage production practices become ready for testing in forage-animal systems and assist in the mathematical modeling of such systems.

MECHANIZATION
RPA 308

METHODS AND EQUIPMENT FOR ESTABLISHING, MAINTAINING AND IMPROVING FORAGE PRODUCTION
RPA 308A

Situation: The wide range in topography, soils and climate in the Southern Region presents a variety of problems in the establishment and maintenance of desirable forage species. Successful establishment of new stands is a primary requisite for minimizing cost of production. Poor stands and slow growth of new forage plantings may often be attributed to inappropriate planting and fertilizing practices. Small-seeded grasses and legumes present serious problems in seedbed preparation and planting require specialized equipment and techniques. Overseeding of pastures, especially sod crops, presents problems quite different from seeding in a fallow seedbed. Research is needed to develop machinery and practices that minimize hazards to crop stands.

Maintaining productive, high quality perennial pastures is often a critical problem and new approaches to renovation are urgently needed. effective equipment for pasture renovation is lacking, and we have very little research information on dependable management practices to ensure longevity of perennial pastures and proper species composition. Control of weeds and brush, evaluation of systems for supplemental irrigation and the potential use of sewage effluent on forage crops present additional opportunities for increasing forage production through research.

Objective: To develop new equipment and practices for establishment, maintenance, renovation and production of high quality pastures.

Researchable Problems:

A. Develop equipment to harvest seed and vegetative reproductive parts of forage crops which will maintain high viability.

B. Develop planting and fertilizing equipment that will permit

precision placement of seed and fertilizer, desired soil compaction and moisture retention.

C. Develop equipment and techniques for successful interplanting and fertilizing in sod crops or undisturbed sites.

D. Develop equipment and practices for renovation and restoration of perennial pastures and control of weeds and brush.

E. Investigate the potential and economics of supplemental irrigation and use of sewage effluent for forage production and the possibilities of developing effective economical equipment for water distribution.

F. Investigate various methods of keeping animals restrained to desired grazing areas.

Potential Benefits: The cost of establishing and maintaining forage production can be reduced substantially. Better stands and rapid establishment will increase the productivity per unit area and result in lower-cost forage. Effective renovation and restoration of productivity of perennial pastures will eliminate the expense of re-establishment and loss of potentially productive land for extended periods of time and increase total production.

METHODS AND EQUIPMENT FOR HARVESTING, PROCESSING, STORING, AND FEEDING FORAGE CROPS

RPA 308B

Situation: Forage growth rate varies from week to week. This results in uneven supplies and varied quality. Thus, harvesting and storing are essential to maintain a high level of animal production. Critical problems exist in the harvesting, processing, storing and feeding of forage crops. Recent research has shown that certain Southern forage grasses can be used as high quality feed ingredients. Additional research is needed in the reduction of moisture content while maintaining high quality. Although silage systems are relatively well mechanized, additional research is needed, especially in the mechanization of bunker or trench silos.

Objective: Develop methods and equipment for processing, storing and feeding forage crops for maintenance of quality with minimum labor, energy and equipment requirements.

Researchable Problems:

A. Investigate practical and economical methods of harvesting to maintain forage quality.

B. Determine the effect of various chemicals on (1) maximum moisture content for safe storage and (2) nutrient and dry matter losses.

C. Develop methods and equipment for treating forage to obtain maximum rate of moisture loss during harvest.

D. Determine equipment and procedures for mechanically drying or dehydrating hay with minimum input of fossil fuels.

E. Develop economical systems for harvesting, processing, storing and feeding hay and/or silage.

F. Develop equipment and procedures for the small producer to harvest and process surplus forage for sale.

G. Investigate methods of harvesting and processing forage produced in aquatic or semi-aquatic conditions, such as disposal lagoons.

Potential Benefits: Higher quality hay and silage will be produced with reduced equipment, labor and energy requirements. This should result in reduced cost per unit of value and permit more efficient use of hay and forage crops.

FORAGE AND PASTURE SYSTEMS

RPA 309

FORAGE AND PASTURE PRODUCTION SYSTEMS USE

RPA 309A

Situation: Effective use of the Southern Region's diverse forage potential will require development of innovative grazing and forage feeding systems with maximum flexibility. The traditional beef industry in the Southern Region has been a weaned-calf producing enterprise and, there is a mass exodus of calves from the farms at weaning time. Many of these calves are exceptionally light-weight, often less than 300 pounds when marketed. An obvious reason for this practice is that economically competitive, sequential year-round grazing systems utilizing superior forages for producing heavy weaned calves, or for growing out lighter stocker cattle have not been generally developed. Forages, particularly warm-season grasses, that have a higher concentration of digestible energy and that are more readily consumed by cattle are being developed. Cattle with higher production potential (i.e., twinning, crossbred, etc.) are becoming more common and obviously have a higher nutrient requirement for production at optimum efficiency than the grade cows now dominating the Southern scene. With these developments and continued demand for animal products, a fully integrated system approach to forage production and utilization will be necessary to provide farmers and ranchers with the production information required for maximum efficiency and dependability.

The production of beef or milk by cattle grazing on pastures involves several biological systems, each quite complex in its own right. The complexity of these systems interfacing and interacting with each other poses critical problems in the formulation and execution of research designed to gain a better understanding of these interactions.

Progress has been made in the past from intensive studies of the component parts of the pasture-beef or milk production systems. Future progress will require a serious research effort to derive certain critical information on the behavior of system components and on their interfacing with other components within the framework of the total system. The behavior of a single component and the interaction of components within the framework of a total system must be measured in terms of animal response. This measurement, to be most useful, must be expressed mathematically in a manner that clearly describes the dynamics of the system. Only a limited number of sequential year—round pasture grazing or pasture grazing-forage feeding systems can be tested. Therefore, it is important that such studies be designed to acquire data suitable for the development of mathematical models of soil-plant-animal relationships or data that will adequately test existing theories concerning these relationships. Such data should then provide a basis for projecting the economic value of alternative systems. To be successful, this research will require a well-planned interdisciplinary approach.

Objective: Develop economically competitive sequential year—round grazing or grazing and forage feeding systems for beef and milk production.

Researchable Problems:

1. Develop and test sequential year—round grazing, or grazing-forage feeding systems, that maximize output:input ratio for producing dairy cows, beef cows of varying production potential producing weaned calves, growing stocker calves and fattening slaughter cattle.
2. Within the framework of a totally integrated beef or milk production program, measure in terms of animal response and express in mathematical form the response to the several components and the interaction between the several components within a sequential year- round grazing or grazing and forage feeding system.

3. With data derived from sequential year-round grazing or grazing and forage feeding systems, develop functional forms and parameter values that express the fluxes necessary to project the value of alternative forage systems for meeting the nutrient requirements of the several classes of cattle.

Potential Benefits: Present production of beef is not adequate to supply world demands. Resources which could be diverted to beef production are limited, both in this country and abroad, but the Southern Region has opportunities through research for sharp increases in beef production. Properly managed year-round forage systems can be developed to meet the requirements for acceptable performance of cows and nursing calves, growing stocker calves and perhaps for fattening cattle. The low ceiling on beef production in the Southern Region can be removed if sequential year-round pasture or pasture and forage feeding systems are developed that maximize the output:input ratio for the life-time production of high producing females and for the production of slaughter cattle.

FORAGE-ANIMAL SYSTEMS ANALYSIS AND MATHEMATICAL MODELING

RPA 309B

Situation: Sound management is the key to realizing the full yield potential of forage plants and the optimum level of animal production for maximum profit. Decision making in the forage-animal production industry is necessarily complex because of the interaction of plant, animal, environment, price structure and the many alternatives available to the operator.

The character of all components of a forage-animal system, the intensity and mode of their interaction and their performance or productivity continually shift through time. To make optimal managerial decisions, both at the individual-operator level and at the policy level, requires quantification of the criteria to be jointly maximized and/or minimized. The essential dynamic nature of the system implies the need for a kind of conceptual framework to guide intensive experimentation and provide a means for rapid, thorough and quantitative analysis of alternative production, management and utilization practices.

Mathematical modeling is the process of translating structural and behavioral concepts into precise mathematical statements. For describing dynamic systems, the pertinent mathematical medium is that of differential and difference equations.

Given a system of differential or difference equations that adequately describes the behavior of the system of interest (here a forage-animal system), given the state of the system at a point in time in terms of the state of each facet, and given the time courses of conditioning factors and rates of input from outside the system, the state and the output rates of the system at any subsequent point in time can be found. High speed computing has rendered feasible the numerical integration required for quantifying complicated dynamic phenomena, and there is rapidly increasing

use of systems of differential or difference equations as models of real-world systems (among the biological fields) and, thence, their integration by computer.

Early attempts to model the physical (biological) aspects of forage and pasture systems have been edifying to a degree and provide, in some cases, excellent bases for further work, but, on the whole, results are far from adequate to satisfy practical management and policy needs. To develop mathematical models takes both theoretical and experimental research. Models are the result of reasoning (theorizing) from facts (most frequently provided through research) and general experience which provide knowledge, insight and intuition about the nature of the system being modeled. Employed in the reasoning are concepts about the structure (components) and the behavior (how the components react individually and interact jointly) of the system. Involved in behavior are inherent features dependent on the nature of the system and imposed features dependent on the forces (inputs and conditioning factors) acting on the system. Practical observation and controlled experimentation enter both the construction and the testing of models, as do concepts from supporting fields.

Once developed, models must be tested in order to know how well they enable prediction of the outputs from a system for given inputs and to provide insight for their improvement. Testing requires the comparison of predicted outputs with actually observed outputs from systems subjected to a variety of given input conditions. Continuing intense research is urgently needed to broaden the scope of quantification and improve its predictive value so that carefully reasoned decisions can be made regardless of the general value (price) structure and local conditioning factors. Thus, mathematical modeling efforts and critical experimentation must go hand in hand, and the personnel involved must enjoy intimate collaborative association.

The framework just outlined is the only way that intensive experimentation and associated theoretical efforts can yield models which encompass the dominant critical features of forage-animal systems and their behavior and which thereby permit satisfactory predictions of total-system behavior under a wide variety of practical management alternatives.

Objectives:

A. To develop theory and associated dynamic mathematical models which quantitatively relate sward and animal productivity and quality of products to forage species mixture, type of animal, soil characteristics and critical environmental, cultural and management practices.

B. To quantify dynamically the reactions of forage-animal entrepreneurs to price structure and the feed back effect of entrepreneur practices on price structure.

Researchable Problems:

1. Development of quantitative theory (dynamic mathematical representations) of sward response in terms of productivity and forage quality to important affecting factors--species mixture, soil characteristics, moisture status, temperature, and, especially, type and rate of defoliation.

   Note: mechanical harvesting is only a special case of defoliation.

2. Development of quantitative theory relating intake rate of forage by animals, and the character of the forage consumed, to type (including size) of animals, character and density (availability) of forage on offer, and amount and type of feed supplements provided.

3. Development of quantitative theory relating digestibility and animal performance to rate of forage consumption, character of forage consumed and type of animal.

4. Quantification of the interrelations between entrepreneur reactions and price structure.

<u>Potential Benefits</u>: Given good models, the performance of forage-animal systems under widely varying actual or potential input situations can be "simulated" and outputs predicted. Thus, a rational basis for optimizing the management of forage-animal systems is provided without always having to perform new experiments whenever conditions call for management changes.

IMPROVED FEED USES OF WARM-SEASON PERENNIAL GRASSES

RPA 407

Situation: In addition to traditional use as pasture and stored feed for livestock, forages have considerable potential for production of highly specialized processed feeds and food supplements for both livestock and man. Although warm season perennial grasses have high yield potential and have provided the basis for the Lower South's beef cow-calf industry, compared to cool-season grasses they are relatively low in digestibility and intake. Present day technology is not adequate to permit maximum effective utilization of our vast forage resource. Information is lacking on the chemical-physical interrelationships between the cell wall constituents (e.g. cellulose, hemicellulose, lignin and silica) and microanatomy of warm-season perennial grasses as related to differences in ruminant digestibility and intake. This information is needed to provide the basis for processing and/or breeding forage of improved nutritive value for livestock.

Traditional protein supplements such as fish and soybean meal are in short supply and are high-priced. Southern grasses fertilized with sufficient nitrogen are high in crude protein, but information is needed on relative extractability of the protein(s) and development of processes to obtain protein concentrates for supplementing livestock diets.

Coastal bermuda and other warm-season perennial grasses are excellent sources of carotene (pro-Vit A) and xanthophyll(s) for poultry rations. However, because of high fiber content, the amount of forage in broiler and layer diets is limited. Development of a process to extract xanthophyll while yielding a fibrous residue suitable for beef cattle should enhance overall utilization of this forage resource. Over 75 percent of the total protein and over 90 percent of the total carotene and xanthophyll in Coastal

bermudagrass is contained in the leaf. A technique for separation of forage into high quality leaf and low quality stem fractions could provide a carotene-xanthophyll source for poultry diets and roughage for beef cattle.

The small dehydration industry in the Southern Region produces only 12% of the dehydrated meal fed annually to livestock and poultry in the region. With expansion of these industries and the export markets (Japan and Western Europe), demand for dehydrated forage products will increase. If dehydrated Coastal bermudagrass products are to compete favorably with alfalfa meal imported from other areas, quality standards for Coastal bermuda products will have to be established. In view of the energy crises, combinations of field curing and mechanical dehydration which results in optimum nutritive value and minimum expenditure of fossil fuel should be investigated.

For the commercial processor, surplus forage harvested as hay and stocked or stored as large bales may permit processing operations to be extended beyond the growing season. Research is needed to evaluate the composition and nutritive value of such forage for use in pelleted and other feed products.

Research needs to be expanded on controlled fermentation of silage directed at improving the digestibility and nutritive value of forages. Forage harvested as low moisture haylage offers an alternative means of preservation and should be investigated. Additional information is needed on pelleted or briquetted forages for complete rations to be mechanically fed. Data is limited on the chemical composition of many Southern forages as relates to nutritive value. Such data will provide the basis for use of Southern forages in computer-formulated, least-cost rations for various classes of livestock.

Forages contain glycosides, alkaloids and other antimetabolites as well as growth promotors and reproductive factors. Maximum utilization of warm-season perennial grasses must include a knowledge of the nature and effects

of biologically active constituents and development of methods for processing forage products of the highest nutritive value.

Objective: To maximize use of forage resources through development of new and improved methods of processing, identification and elimination of deleterious substances, development of new specialized feed products and low-cost methods to increase biological availability of important nutrients.

Research Approaches:

A. Determine the need for improved forage products (project market) for the region's expanding livestock and poultry industry as a basis for development of improved forage products.

B. Investigate interrelationships between various cell-wall components (cellulose, hemicellulose, lignin, silica, etc.) which relate to digestibility and voluntary intake to provide a basis for improving the nutritive value of warm-season perennial grasses.

C. Investigate protein(s) of warm-season perennial grasses and develop processes to obtain protein concentrates for feeding to poultry and swine.

D. Investigate the composition of warm-season perennial grasses as influenced by management and processing practices in order to establish quality standards under which various forage products may be marketed (both domestic and export) as well as utilized in a systems approach to livestock production in the region.

E. Investigate the separation or fractionation of warm-season perennial grasses into various components (e.g. leaf-stem fractions, xanthophyll-carotene extracts, protein concentrates and fibrous residues) for more efficient utilization in the formulation of "complete rations" for particular classes of livestock including the supplementation of these fractions with urea and other additives

to achieve balanced rations at least cost.

F. Investigate controlled fermentation of warm-season perennial grasses to improve nutritive value and provide more feed from forage, thereby minimizing dependence on grain and conserving energy required to mechanically dehydrate. Use of low quality forage as an energy source in production of single cell protein would also be investigated.

G. Identify and investigate removal or neutralizing of deleterious substance(s) in forage (e.g. polyphenolics, alkaloids, mycotoxins) which limit animal performance and identify possible growth and reproductive factors which enhance nutritive value.

H. Improve the biological availability of carbohydrates through treatment with enzymes and other additives.

I. Investigate ways to optimize nutritive value of harvested forage and conserve energy output required to process forage by preserving forages as high moisture products, opening stomata of forages to reduce moisture content of standing crop and combinations of solar and mechanical dehydration.

Potential Benefits: The economic impact gained from full and efficient utilization of the potential feed products contained in the South's vast forage resource is enormous. Direct benefits from this research include lower production costs and consumer prices for meat and dairy products, expansion of markets for forage products and development of new high protein and other food sources. Prevention of nutrient losses, utilization of valuable plant nutrients presently wasted or incompletely digested and conversion of materials to higher quality products would benefit both farmer and consumer.

DETECTION AND ESTIMATION OF PESTICIDE RESIDUES IN ANIMAL PRODUCTS AND FEEDS

RPA 408

Situation: Most pesticides and their metabolites, when applied to livestock either dermally or orally, deposit residues in the tissues. The chlorinated hydrocarbons (rapidly being removed from usage) are especially bad in this respect; a great number of them are primarily fat soluble, and their persistence is great. In fact, if one animal containing residues is consumed by another animal, the residues will deposit in the second animal and thus might be passed along through several links in the food chain.

The organophosphates generally are more toxic, but fortunately the deposition of residues is much less and the duration is shorter than that of the chlorinated hydrocarbon pesticides.

Quantitative chemical analysis of animal tissues is expensive, laborious and time consuming; analysis of milk for residues is generally cheaper, easier and shorter. There is a great need for simpler and less expensive procedures. Procedures could be less time consuming if results were qualitative and not quantitative.

Objective: To develop fast, simple, inexpensive methods for routinely checking animal tissues and feeds for pesticide residues.

Researchable Problems: Pesticide residue analysis consists of 3 basic operations:

A. Extraction of the pesticide from the material with a suitable solvent or mixture of solvents.

B. Separation and cleanup of the pesticide in the extract from interfering materials by partitioning between 2 immiscible solvents, followed by column chromatography or some other system of cleanup.

C. Analysis or quantitation of the clean extract, usually by gas, paper, or thin-layer chromatography, radio-assay, or other means.

Each step will need to be studied in detail to shorten and simplify it and, at the same time, retain the accuracy by: (1) evaluating extraction procedures on the basis of simplicity and effectiveness, (2) designing fast and routine cleanup procedures for separation of interfering substances and (3) developing means of quantitation which are fast, sensitive and inexpensive.

Potential Benefits: Since it is mandatory that foods be free of harmful residues, rapid and inexpensive techniques for monitoring agricultural products would provide essential information on residues at minimum cost to the producer and the consumer. Through the development of these techniques (1) agricultural products could be monitored at much lower costs and (2) more samples could be analyzed for residues.